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## Distributed Trust & Reputation Models using Blockchain Technologies for Tourism Crowdsourcing Platforms

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### Abstract

Crowdsourced repositories have become an increasingly important source of information for users and businesses in multiple domains. Everyday examples of tourism crowdsourcing platforms focusing on accommodation, food or travelling in general, influence consumer behaviour in modern societies. These repositories, due to their intrinsic openness, can strongly benefit from independent data quality modelling mechanisms. In this context, building trust & reputation models of contributors and storing crowdsourced data using distributed ledger technology allows not only to ascertain the quality of crowdsourced contributions, but also ensures the integrity of the built models. This paper presents a survey on distributed trust & reputation modelling using blockchain technology and, for the specific case of tourism crowdsourcing platforms, discusses the open research problems and identifies future lines of research.

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### 1. Introduction

Data crowdsourcing has become a major source of information in multiple domains. Everyday, examples of crowd-sourced data applications such as accommodation, food or media contents abound and, above all, have large influence over consumer behaviour in modern societies. People chose hotels, restaurants, or movies based on the “wisdom of the

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crowd”. However, as the amount of data increases, so does the information overloading and the user ability to discern among options and make rational choices. Typically, crowdsourcing platforms raise trustability questions since they neither store user background data, nor adopt reliable technology, making recommendation particularly hard to rely on. Nowadays, false data in crowdsourcing platforms distort important social decisions related to politics, media, and life in general. As such, trust & reputation modelling has arguably become a core research area in data science. It can be used to establish the quality of the crowdsourced information and the trustworthiness of the contributors.

To ensure data authenticity, *i.e.*, avoid manipulation from unethical stakeholders, blockchain should be a key support technology of any crowdsourcing platform. By uniquely associating contributors to contributions, blockchain ensures data authenticity and traceability. It facilitates the process of recording transactions – on-line reviews, orders, payments, account tracking – and tracking assets in a network. The adoption of blockchain technology prevents against malicious behaviours and ensures the reliability of transactions. Developing crowdsourcing platforms with built-in trust & reputation modelling supported by blockchain will arguably have a substantial impact to the quality of the information provided, *e.g.* travellers will be able to rely on the available reviews when booking hotel, readers will be able to trust news curated by other readers or e-customers will be able to trust the reputation of a product, service or provider.

This paper surveys trust & reputation systems supported by blockchain technologies and, then, identifies the main challenges within tourism crowdsourcing platforms. The main goal is to compare existing models and detect future research trends to ensure the quality and authenticity of tourism-related crowdsourced data.

The rest of this article is structured as follows. In Section 2 we describe a systematic literature review on trust & reputation models using Blockchain technology. In Section 3, we identify the main challenges associated with the distributed trust & reputation models. Finally, Section 4 details the research trends on blockchain-based trust & reputation models.

## 2. Related Work

Blockchain is a distributed and decentralised public ledger, *i.e.*, it is a sequence of blocks holding all transaction records, working as a conventional public ledger. This technology ensures that the transactions are: (i) encrypted; (ii) validated; (iii) stored by multiple entities; and (iv) immutable. It has been applied to a wide spectrum of applications, ranging from cryptocurrency, financial services, risk management, Internet of Things to social services [9]. According to Pilkington [8], blockchain grants: (i) decentralised immutable and traceable reputation; (ii) unique users, *i.e.*, only registered users can contribute with ratings or reviews; and (iii) portable and transverse reputation. In addition, the analysis of the reviews and the reviewers reputation can indicate the reputation of the service itself. Therefore, an higher reputation indicates higher service quality, allowing, for example, the provider to increase the price [7].

The application of blockchain to crowdsourcing platforms is relatively new. The five works found in the literature [2, 1, 3, 6, 5] were published since 2017. They include three works on trust [2, 6, 3] and two on reputation [1, 5]. Regarding the blockchain technology used, four use Ethereum open source framework [1, 3, 6, 5] and one relies on a proprietary solution [2].

- Buccafurri et al. [2] developed in 2017 a blockchain protocol called tweetchain to encode transactions and create meshed replications for a twitter-based application.
- Bhatia et al. [1] described in 2018 a reputation model for a crowdsourcing platform using the Ethereum blockchain. The crowdsourcing platform is a talent pool, where candidates can find jobs.
- Lu et al. [6] presented in 2018 ZebraLancer, a freelancer service finder and service payment crowdsourcing platform, which keeps transactions private and anonymous. This platform builds a trust model and implements the Ethereum blockchain technology.
- Fernández-Caramés and Fraga-Lamas [3] reported in 2018 a decentralised blockchain framework for storing medical health information. The blockchain Ethereum framework was applied to keep patient records private and to model the trustworthiness of the medical staff.
- Li et al. [5] proposed in 2018 a decentralised crowdsourcing job finding and posting platform. The authors adopted the ethereum to build the distributed reputation model based on the past behaviour of each professional.

Table 1 presents the comparison of the crowdsourcing platforms in terms of trust & reputation model used, blockchain technology adopted and domain of application.

Table 1. Crowdsourcing platforms that adopts blockchain technology

Contribution	Model	Blockchain Technology	Domain
Buccafurri et al. [2]	Trust	Tweetchain	Twitter
Bhatia et al. [1]	Reputation	Ethereum	Job Finding
Lu et al. [6]	Trust	Ethereum	Payment System
Fernández-Caramés and Fraga-Lamas [3]	Trust	Ethereum	Health
Li et al. [5]	Reputation	Ethereum	Job Finding

This literature survey shows that there are few crowdsourcing platforms concerned with ensuring the quality and authenticity of the crowdsourced data. In particular, in the tourism domain, where crowdsourcing is extremely popular, no such mechanisms are found in the prevailing platforms. For this reason, the following sections will specifically address the case of tourism crowdsourcing platforms.

### 3. Main Challenges

Tourism is an enriching activity which fosters relaxation and well-being. Not only personal intellectual satisfaction tends to increase with enriching travelling experiences, but the tourism industry promotes the economical development of countries. Therefore, the exploitation of the trustworthiness and authenticity of tourism data is relevant both to individuals and society. In this context, integrative, scalable approaches to trust & reputation modelling can take advantage of blockchain technology, overcoming the vulnerability of traditional computational approaches. This scenario raises multiple research questions:

1. How does false information affect tourism crowdsourced platforms?
2. How to ensure the trustworthiness of the tourism crowdsourced information?
3. Which are the most suitable processing methods to support decentralised modelling algorithms?
4. Does blockchain-based trust & reputation modelling improve the reliability of tourism crowdsourced platforms?

On-line trust & reputation are built over time based on quality and amount of contributions. While trust defines the reliability of users and resources based on direct experience, reputation is based on third party experiences, *e.g.*, the crowd [4]. According to Önder et al. [7], the modelling of the reputation of contributors defines the quality of the service itself, which can be used for pricing purposes. However, since the overwhelming majority of crowdsourcing platforms does not ensure the authenticity of the volunteered data, trust & reputation models can suffer from malicious contributions. To explore the above problems this study proposes using blockchain together with trust & reputation modelling.

### 4. Research Proposal

The proposed methodology for tourism crowdsourcing platforms integrates the blockchain technology with trust & reputation modelling. By incorporating the blockchain principles, the transactions become encrypted, validated, stored by multiple entities and immutable. The trust & reputation modelling grants quality assessment of the reviews and reviewers and, ultimately, of services. To process, exploit and discover trends in crowdsourced data, such platforms need:

- **Data collection:** Collect and store the crowdsourced data in the blockchain.
- **Data processing:** Build trust & reputation models and explore big data techniques, including data stream processing techniques, using a scalable cloud computing environment.
- **Data analysis:** Perform multiple-criteria analysis to identify patterns and trends in user behaviour.

- **Validation:** Use predictive accuracy metrics, such as Root Mean Square Error (RMSE) and Mean Absolute Error (MAE), and classification metrics like Precision, Recall and F-Measure to determine the quality of recommendations and, consequently, of the trust & reputation models.

By ensuring the authenticity of the shared information, building trust & reputation models of contributors and maintaining a traceable history regarding all crowdsourced contributions, the current research proposal aims to enrich the traveller experience by providing reliable information. This stems from the fact that the personal recommendations issued by these platforms depend on the quality and authenticity of the crowdsourced data.

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